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SHARED VIRTUAL DESKTOP COLLABORATIVE
APPLICATION SYSTEM

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<u>Background of the Invention</u>

<u>1. Field of the Invention:</u>

The present invention is generally related to computer systems that provide for the inter-networked simultaneous sharing of information and, in particular, to a collaborative computer application system that provides for a virtual shared application space.

<u>2. Description of the Related Art:</u>

With the recent expansion in the variety of information technologies and the distribution of information among network interconnected, or inter-networked computer systems and users, a need has arisen to coordinate the exchange and development of information by users typically at separate and potentially heterogeneous computers systems. In many of these instances, the information that needs to be shared or created requires the collaborative or effectively simultaneous use of some particular application. In many of these instances, the application has been originally designed and implemented to utilize a virtual display window created within and managed by a graphical user

1   interface (GUI) based operating system. Many implementations of such operating

2   systems are well known and include the Apple Macintosh System 7 operating

3   system, the MicroSoft MS-Windows 3.1, MS-Windows 95, MS-Windows NT, and

4   the XWindows system, originally developed at MIT and used in many Unix based

5   operating systems, including SunOS and Solaris.

6

7   The virtualization of the display in the form of a window permits some

8   small conventional degree of flexibility in controlling where underlying data and

9   programs are stored, whether an application program is locally or remotely

10   executed and whether the display window or windows utilized by the particular

11   application are locally or remotely displayed. Although these degrees of flexibility

12   are conventionally available, collaborative use of an application program to

13   interactively or simultaneously exchange and create information is not effectively

14   supported. Conventional application programs remain by and large single user

15   tools.   As such, these applications co-exists in a networked environment

16   constrained to sharing data through low level record and file locked access to

17   shared data on network accessible storage devices.

18

19   Conventional collaborative application programs have been designed and

20   implemented in an effort to support a greater degree of concurrent interactivity.

21   Most conventional collaborative applications are highly proprietary in that the

22   manner and nature of the permitted collaboration is strictly controlled by the

23   particular application. Collaborative interaction is confined to the functions of

24   that application. One manner by which such applications operate is through the

25   establishment of a background server accessible by way of a network connection

1   from each host that will participate in a collaborative session. On each

2   participant host, a user executes an identical copy of the collaborative application.

3   The application itself is responsible for initiating or joining a collaborative session

4   by registering with the background server through a proprietary protocol, though

5   typically overlaid on a conventional protocol such as TCP/IP. Thereafter, for the

6   duration of the collaborative session, the application is responsible for duplicating

7   all collaborative user input to the application and forwarding the copied input to

8   the background server. In turn, the background server is responsible for re-

9   distribution of all collaborative input from each participating host to all other

10   participating hosts. Thus, each of the collaborative applications operate from the

11   cumulative set of collaborative user input. Consequently, each application is

12   expected to operate and present information in a synchronized manner.

13

14   Proprietary collaborative application programs, while generally functional

15   for their intended purposes, are of limited collaborative value because the

16   collaborative function supported is specifically limited to that of the particular

17   application. Often, the particular requirements of a specific collaborative

18   application program, in order to function as intended, may bar the use of other

19   collaborative applications at the same time by the participating hosts.

20   Furthermore, a high degree of administrative overhead, if not also computer

21   processing overhead, is often required to support collaborative application

22   programs. These costs are additive to the processing and administration

23   requirements of the underlying operating system and networking support required

24   by the application. Thus, collaborative applications have been effective most

1   typically in situations where specialized use and particular functionality have been

2   required.

3

4   An alternative to the use of proprietary collaborative application programs

5   is a technology known as screen sharing. This technology provides for the

6   information displayed on the display of a primary or host computer system to be

7   projected across a network to another, or guest computer system. In general,

8   screen sharing is implemented through establishment of a logical tap at the

9   display device driver level of the host computer system. All display data is

10   duplicated by way of this tap and passed through the network to the guest. On

11   the guest system, the screen sharing application executes a logically inverse data

12   tap to display the monitored screen data on the display of the guest.

13

14   Screen sharing therefore operates largely independent of the particular

15   applications being executed on the host in addition to the screen sharing

16   application. Screen sharing allows application independence to the point that

17   collaborative sharing of well behaved though otherwise ordinary applications,

18   including applications that otherwise could not be executed on a particular guest

19   system, can be made subject to the collaboration.

20

21   Unfortunately, conventional screen sharing effectively precludes the private

22   co-execution of other applications on both the host and all guest systems during

23   the collaboration. All user input on both the host and guest systems is provided

24   to the host executed applications. Thus, the entire function of the host and guest

25   appears synchronized and limited to the collaboration. Consequently, screen

1   sharing is predominately used to allow remote systems to monitor the display

2   oriented aspects of the execution of applications on a single host system.

3

4   Another form of computer based collaboration is known as window

5   sharing. In collaborative window sharing, the host system executes an otherwise

6   conventional application within a window established and managed by a

7   proprietary window sharing collaborative application. As with screen sharing, the

8   principal operative feature of window sharing is a tapped duplication of the

9   window display data for transfer to one or more guest systems participating in the

10   window sharing collaboration. Each of these guests also executes the window

11   sharing application, though configured to receive and display the tapped data in

12   a similarly configured window on the guest system. Since a single application is

13   being executed within the logical confines of the shared window, guest input data

14   can also be tapped and provided to the local host at least in a two system

15   collaboration session. If more than two systems are to participate share input

16   data in a collaboration, a significantly more complex registration and input server

17   system is generally required.

18

19   The window sharing technology is further constrained in general by the

20   limitation that only a single application can be collaboratively shared within a

21   single window. A collaboration session could be realized through a single window

22   by execution of a succession of applications. To avoid the need to stop and restart

23   applications, multiple windows may be supported by the window sharing

24   application. As expected, the co-execution of applications in respective windows

25   will contend with one another for system resources. However, the execution

1 behavior of the shared applications may be unusual due to the potential of

2 unexpected inputs. A first application may be executed on the host computer

3 system and shared with one or more guests. If the user of that system changes the

4 local input focus to a second window, corresponding to either a private, locally

5 executed application or to another shared application window, the focus event will

6 typically suspend execution of the first application until a focus event within the

7 application's window returns execution focus to the first application. While

8 suspended, the shared application will refuse all input except for a focus event,

9 such as a mouse click within the shared window. Thus, all collaborative guests

10 are suddenly and unexpectedly stopped in the midst of their collaboration.

11

12 A shared application focus event may also be generated on any of the

13 guest systems. Consequently, a shared window may be suddenly and

14 unexpectedly raised to active execution on the host by a guest focus event. That

15 is, each time any collaborator at the host or any guest system introduces a focus

16 event into a guest shared window, focus and execution will immediately switch to

17 the shared application on the host and all guests. If multiple shared applications

18 are being co-executed on the host, the contention for focus will be substantial.

19 Thus, users at the host and guest executing one or more shared applications may

20 be sharply limited if not barred as a practical matter from co-execution of other

21 applications, shared or private. This characteristic of window sharing is, in

22 general, poorly received by the users of such applications.

23

24 A combination window and screen sharing technology is also known. This

25 technology provides for the sharing of the full screen on the host. The shared

1 screen is, however, displayed in a window on a guest system. By sharing the full

2 host screen, multiple host executed applications can be shared within a single

3 collaboration session. Input events are mapped on the guest system to be window

4 frame relative for events within the shared window. Consequently, a reasonably

5 operative desk top is represented on the guest in the shared window.

6

7 However, the combined window and screen sharing technology inherits

8 most if not all of the disadvantages of the individual screen sharing and window

9 sharing technologies. On the host, no private applications can be executed since

10 the entire screen is shared. While focus events from a guest outside of the guests'

11 shared window will not be shared with the host, all host focus events will generate

12 shared window focus events on a guest. Thus, any activity on the host or through

13 the host from potentially other guests will raise the shared windows of all guests.

14 The ability to execute private applications on the guest systems is therefore largely

15 defeated.

16

17

18 <u>Summary of the Invention</u>

19 Thus, a general purpose of the present invention is to provide a virtual

20 shared application space that enables collaborative information exchange.

21

22 This is achieved in the present invention by provision of a computer system

23 that executes first and second sets of application programs. The computer system

24 includes a processor that includes an input device and an output device and an

25 operating system executed in support of the execution of programs. The

1   operating system includes a graphical user interface coupleable through an

2   output driver to the output device and an input interface including an input queue

3   coupleable through an input driver to the input device. The operating system also

4   includes a first list of a first set of application programs executable by the

5   processor and a second list of application program windows corresponding to the

6   first set of application programs. An environment manager program is also

7   executed by the processor. The environment manager includes a third list of a

8   second set of application programs and a fourth list of application program

9   windows corresponding to the second list of application programs. Execution of

10   the environment manager provides for selectively swapping with the operating

11   system the first and third lists and the second and fourth lists to switch between the

12   execution of the first and second sets of application programs.

13

14   Thus, an advantage of the present invention is that a functional virtual

15   application space is created.

16

17   Another advantage of the present invention is that a consistent, complete

18   user environment is created.

19

20   A further advantage of the present invention is that the relationship

21   between the shared virtual application space and the non-shared application

22   spaces of inter-networked computer systems mutually inter-operate in well defined

23   and consistent manner.

24

1   Yet another advantage of the present invention is that the shared virtual
2   application space maintains an independence from the specific devices that
3   provide input events, provide for display outputs and establish the inter-
4   networking between collaboratively operated computer systems.

5

6   A still further advantage of the present invention is that a collaborative
7   environment manager can be provided in the form of an application, device
8   driver, system library or combination thereof to establish a collaborative shared
9   virtual application space fully consistent with the normal operation of a native
10   operating system executed by a given computer.

11

12   Still another advantage of the present invention is that the system
13   architecture employed to establish the shared collaborative application space is
14   consistent with the implementation of generic graphical user interfaces, thereby
15   permitting collaborative operation on heterogeneous systems.

16

17   Yet still another advantage of the present invention is that the inter-
18   networking communication between collaborative systems is optimized and readily
19   inclusive of incorporating fully collaborative participation by multiple computer
20   systems in the shared application space.

21

22

23   Brief Description of the Drawings

24

1   These and other advantages and features of the present invention will

2   become better understood upon consideration of the following detailed

3   description of the invention when considered in connection of the accompanying

4   drawings, in which like reference numerals designate like parts throughout the

5   figures thereof, and wherein:

6

7   Figure 1a is a schematic block diagram of a computer system suitable for

8   use with the present invention;

9

10   Figure 1b is schematic block diagram of an event driven operating system

11   supporting a graphical user interface consistent with the utilization of the present

12   invention;

13

14   Figure 2 is a simplified schematic block diagram of the components of a

15   collaborative application environment manager consistent with the present

16   invention;

17

18   Figure 3 provides a simplified block diagram illustrating the establishment

19   of overt and covert operating environment and shared participation in both by the

20   environment manager application of the present invention;

21

22   Figure 4 provides a schematic block diagram illustrating the

23   implementation and operation of the present invention in establishing the covert

24   display environment;

25

1   Figures 5a and 5b provide graphical representations of the relationship

2   between the overt and covert windows established by the environment manager

3   of the present invention;

4

5   Figure 6 provides a flow diagram illustrating the relevant coercion of the

6   event manager of an event driven operating system consistent with the present

7   invention;

8

9   Figure 7 provides a flow diagram illustrating the modified event handling

10   loop for the overt environment and a single covert environment in accordance

11   with a preferred embodiment of the present invention;

12

13   Figure 8 provides a detailed flow diagram of the input event subsystem of

14   an event driven operating system consistent with the present invention; and

15

16   Figure 9 provides a flow diagram illustrating the modified input handling

17   routine implemented in accordance with the preferred embodiment of the present

18   invention.

19

20   Detailed Description of the Invention

21

22   A computer system 10, as shown in Figure 1a, is suitable for use in

23   execution of an event driven operating system supporting a graphical user

24   interface appropriate for use in connection with the present invention. The

25   computer system 10 includes a micro-processor 12 for executing an operating

1   system and one or more application programs stored in a memory system 14 and

2   accessible by way of an inter-connecting data and control bus 16. Display

3   information is processed through a display controller 18 for rendering on a

4   display 20. Inter-networking communications data is processed through a

5   network interface controller 22 to a network 24. A minimum, though presently

6   preferred, implementation of the interface controller 22 is as a standard serial

7   port providing an inter-networking path over a point-to-point serial path 24. The

8   preferred serial connection, along with the relative simplicity of selecting particular

9   guests for collaboration, is preferred as fully sufficient for collaborative sessions

10   established with the use of digital simultaneous voice and data (DSVD) modems.

11   The interface controller 22 may also be an ethernet or similar local area network

12   (LAN) adapter providing for connectivity to a conventional ethernet network 24.

13   Finally, an input interface controller 26 is provided to receive input data typically

14   from a mouse 28 and a keyboard 30. The interface controller 26, as in many

15   conventional implementations, includes a serial port and a dedicated keyboard

16   controller.

17

18   Conventional computer systems generally sufficient to provide the basic

19   system requirements of the computer system 10 include personal computers

20   based on the IBM AT architecture and derivatives thereof, Apple Macintosh and

21   PowerPC computers, and Sun SparcStations, among others.

22

23   Referring now to Figure 1b, a representative diagram of an event driven

24   operating system 40 supporting a graphical user interface (GUI) is shown. The

25   operating system 40 provides both input and output control services for a number

1   of applications 42_1-42_n that are executed by the computer system 10 with the

2   support of the operating system 40. Characteristic of the operating system 40 is

3   that input data is received and stored by the operating system as discrete events

4   in an input queue 56. As events, each input datum is stored in the input queue

5   with an effective identification of the data source and the data destination. The

6   data destination information may be subsequently utilized by the operating system

7   40 to release the data to the appropriate application 42_1-42_n for which the data

8   is intended.

9

10   An input handler routine 58 is typically provided as a part of the operating

11   system 40 to manage the receipt of input data and to appropriately store the data

12   in the input queue 56. The input handler executes typically in response to the

13   receipt of a hardware interrupt generated coincident with the receipt of input data.

14   The input handler 58, in turn, obtains the input data, creates an identifier as to the

15   source and destination of the data, and stores both as an entry in the input queue

16   56. Each entry in the input queue 56 is, in the preferred embodiment, a list

17   element in a linked list data storage structure or equivalent.

18

19   The operating system 40 also preferably contains a data structure 60 that

20   provides slotted entries for each of the applications 42_1-42_n that have been

21   launched for execution with the support of the operating system 40. Each of the

22   slotted entries in the application list 60 contains identifying information locating

23   each of the applications 42_1-42_n within the address space of the operating system

24   40. The slotted entries also store other information as may be required by the

25   operating system to establish and maintain the memory space and effective

1 execution state of each application. A slotted entry in the application list 60 is

2 typically allocated or initialized upon launch of a new application. As the

3 application is loaded into memory within the address space of the operating

4 system 40, memory is allocated based on the memory space requirements of the

5 application. Appropriate identifiers for this information are entered into the

6 slotted entry for the application in the application list 60. Once loaded, state

7 information also typically stored in the slotted entry is initialized to identify the

8 application as ready to run.

9

10 When an application is terminated, the corresponding memory space

11 identifiers are utilized to release the memory occupied by the application for

12 subsequent use by the operating system 40. The entry in the application list 60

13 is either deleted or marked as unused.

14

15 Typically, a dynamically allocated hierarchical or tree structured window

16 list is utilized by the operating system 40 in management of the windows W_1-W_n

17 that are opened upon request by the applications 42_1-42_n. The windows W_1-W_n

18 are, in the preferred embodiment, allocated within the address space of the

19 respective applications 42_1-42_n and initialized with a logical representation of a

20 window display. The window memory is allocated in response to operating system

21 calls made by the executing application through the application program interface

22 (API) of the operating systems 40. Other calls can also be made by the

23 application to specify various window decorations and to establish callbacks to the

24 application upon user manipulation of the associated window decorations

25

1   With each call to create a window, the operating system 40 adds a list entry

2   to the tree structured window list. The logical root of this window list is the desktop

3   or root window of the operating system 40. Typically, a single word of data,

4   utilized as a pointer to the root window list entry of the tree structured list, is stored

5   in a root window pointer location 62. The root pointer is initialized to point to a

6   root window list entry. The root window entry, like all other tree structured window

7   list entries, typically includes structure links sufficient to allow a linked list type

8   traversal of the tree structured window list by the operating system 40. Traversals

9   of the window list are performed by the operating system 40 to determine window

10   boundaries and visibility in connection with display update events, for example.

11

12   Each entry in the window list also provides storage for a pointer reference

13   to the base of a window memory space W_1-W_n existent within a corresponding

14   application 42_1-42_n. Thus, as each application window W_1-W_n is created,

15   additional window list entries are allocated and linked below the root window to

16   form the tree structured window list. By the ordered linkage of the entries, a

17   hierarchical relation is established representing the desired display window

18   hierarchy over the root or desktop window.

19

20   Another data word is separately stored by the operating system 40 in an

21   active window pointer location 64. The pointer reference stored in the location 64

22   may be a pointer into the application entry list 60 or directly to a particular

23   application in memory. This referenced application is identified as the currently

24   executing foreground application. As such, the application is also the one

25   application that currently has the input focus of the operating system 40. Any

1   other applications may continue to effectively execute in the background as

2   supported by the operating system 40, at least until user input is provided. In

3   general, the application that is executing within the window with input focus

4   receives normal keyboard and mouse input data. Events that are specified to

5   change the input focus, such as a mouse click in another window, may shift the

6   input focus to another window and therefore direct input to another application.

7   With each change in input focus, the pointer stored in the active window pointer

8   location 64 is correspondingly updated to reference the new active foreground

9   executing application.

10

11   Finally, the operating system 42 preferably provides for the storage of a

12   drawing routine table 66. This table 66 is utilized as a jump table permitting

13   integration of a device specific display driver with the virtual display drawing

14   operations internally supported by the operating system 40. In the preferred

15   embodiment, an executing application 42_1-42_n may issue an series of virtualized

16   API drawing command calls to the operating system 40. These calls are generally

17   intended to direct the operating system 40 to make corresponding modifications

18   to the contents of a the window of the requesting application. Where the display

19   area of other windows may be affected by the requested window modifications,

20   as may be determined from a traversal of the window list, update events are

21   queued for the applications owning the affected windows.

22

23   The operating system 40 processes each of the virtualized drawing

24   commands into a series of one or more well-defined atomic drawing operations.

25   These atomic operations are implemented by sub-routines within a device driver

1   46 and are intended to incorporate the hardware specific drawing and display

2   functions of the display hardware 48. In order to integrate these atomic drawing

3   routines into the function of the operating system 40, the drawing routine table 66

4   is used to store execution jump pointers to the individual display controller specific

5   sub-routines 46. The table 66 is initialized with these jump addresses upon the

6   original loading and initialization of the display driver 46 by the operating system

7   40. Thereafter, the atomic drawing commands are accessed through low level

8   API calls by the operating system 40 to physically reflect the logical state of the

9   data stored within the window address space W_1-W_n of the originally requesting

10 application 42_1-42_n.

11

12 The display driver 46 drawing commands perform corresponding drawing

13 operations on the provided display data. The resulting bit map representation of

14 the display data is written to the video buffer space present on the display

15 hardware 48. The display data is provided by the operating system 40 as needed

16 to maintain the currency of the logically visible portions of the windows W_1-W_n.

17 That is, applications will process display update events or other events that

18 ultimately require the updating of a portion of the display to reflect an exposure

19 of a portion of a window or to change the display contents of a window. In either

20 instance, the operating system 40 is called upon by the applications 42_1-42_n to

21 cause operating system 40 to issue a series of atomic drawing commands. The

22 commands issued and data associated with the commands is determined in part

23 by a partial or complete traversal of the tree structured window list whose root is

24 currently pointed to by the tree root pointer 62. As the tree structure is traversed,

25 the visible portion of the windows W_1-W_n are determined by the operating system

1   40 and transferred by execution of atomic drawing commands to the video buffer

2   memory on the display hardware 48.

3

4   Finally, for purposes of the present invention, a communication driver 50

5   is preferably provided in conventional connection to the operating system 40. The

6   communication driver 50 and associated communication hardware 52 may be

7   implemented as a simple serial data sub-system or as a more complicated local

8   area network sub-system. In the preferred embodiment of the present invention,

9   the communication driver 50 is implemented as a serial port driver routine and

10   the communication hardware 52 is a conventional serial port. Thus, the external

11   data connection 54 represents a point-to-point serial link connecting the system

12   38 to a second computer system 10' also executing a functionally equivalent

13   system 38'. The operating system 40 may be called by an application 42_1-42_n to

14   establish a logical connection between the application and the serial port drive

15   routine. This data received by the serial port communication hardware 52 is

16   routed by the operating system 40 to the application 42_1-42_n typically through a

17   data queue dedicated to the port.

18

19   Alternately, the communication driver 50 may include a PC-TCP/IP stack

20   with an appropriate data link layer for managing the operation of an ethernet

21   network interface adapter 52 or token ring network interface adapter. The

22   network 54 can thus provide for the interconnection of one or more other

23   computer systems 10' each executing a local copy of the system 38'. Again, the

24   operating system 40 provides a logical relation between the application and the

25   communication hardware 52, further augmented by the use of internet protocol

1 (IP) addresses or the like. Thus, received network data is routed through a

2 dedicated network data queue to the correct destination application 42_1-42_n.

3

4 The system 10' may also be constructed with a quite different hardware

5 architecture and execute a different operating system 40' so long as the systems

6 38, 38' are logically consistent in their implementation of present invention.

7

8 Referring now to Figure 2, an environment manager application 42_3

9 appropriate for execution within an environment supported by the event driven

10 operating system 40 is shown. The environment manager application 42_3

11 incorporates a number of data structures and support sub-routines appropriate

12 to implement a preferred embodiment of the present invention. The environment

13 manager application 42_3 includes an alternate or covert application list 70

14 equivalent in logical structure to application list 60, an alternate storage location

15 72 for storage of a root window pointer to an alternate tree structured window list,

16 and in an alternate active window storage location 74 for storage of an alternate

17 active window pointer. The environment manager application 42_3 further includes

18 an alternate input queue 76 and a modified input queue handler routine 78.

19 Finally, the application 42_3 includes an alternate drawing routine jump table 80

20 and a covert environment device driver 82 containing an alternate set of well-

21 defined atomic drawing routines. The entry points for these alternate atomic

22 drawing routines are stored in the conventional sequence in the alternate jump

23 table 80.

24

1   The purpose of the alternate data structures and routines provided as part

2   of the environment manager application 42_3 is to permit, in general terms, a

3   swapping of the original or overt structures and routines with the alternate or

4   covert structures and routines on a dynamic basis to switch the global context of

5   the operating system 40 between a overt environment involving the execution of

6   one set of applications and a covert environment involving the execution of a

7   second set of applications. The overt environment applications execute within the

8   normal environment of the operating system 40 as conventional private or entirely

9   locally executed applications on the host 10. The covert environment applications

10   are also executed on the host 10 as local applications, but subject to

11   environmental modifications that enable the sharing of input events and atomic

12   display commands among any number of collaborative guests 10' and the host

13   10. That is, in combination with the swapping in of the covert data structures and

14   routines, local or server input events as well as remote or guest input events from

15   the collaborative guests 10' are collected and provided as input events to the

16   applications in the covert environment. At the same time, all atomic drawing

17   commands are directed to the covert display device driver 82 which is specifically

18   modified to utilize the memory space of the environment manager application

19   window W_3 as a display data buffer for the covert environment display. The root

20   display space of the covert environment is thus presented within the overt

21   environment as the displayed contents of environment manager application

22   window W_3.

23

24   The atomic drawing commands are also forwarded by operation of the

25   covert display driver through the environment manager 42 and operating system

1   40 to the collaborative guests 10' to correspondingly update a client collaborative

2   application window W_3'. That is, the environment manager applications 42_3 of

3   the collaborative guests 10', upon establishing a serial or network connection with

4   the host 10, configures a client collaborative application window W_3'. All input

5   events in this window W_3' are forwarded through the environment managers $42_3'$

6   and operating system 40' over the network 24 to the host 10. All atomic drawing

7   commands forwarded by the host 10 are, in turn, applied by the environment

8   managers $42'_3$ to the operating system 40' to update the contents of the client

9   collaborative application window W_3' on the collaborative guests 10'.

10

11   As schematically indicated in Figure 3, a preferred embodiment of the

12 present invention particularly suited for execution in an MS Windows 3.1

13 operating system environment provides for an overt environment 90 and a covert

14 environment 92.   The overt environment 90 may include any number of

15 executable applications OA_1-OA_N.   Likewise, the covert environment 92 may

16 include any number of covert executable applications CA_1-CA_N. The total number

17 of overt and covert environment applications are naturally limited by the total

18 application space supported by the operating system 40.

19

20   As shown in Figure 3, for operating systems 40 that support cooperative

21 multi-tasking such as MS-Windows 3.1 and Macintosh System 7, an application

22 embodying the present invention is provided to execute in both the covert 90 and

23 overt 92 environments. Thus, at each opportunity for the shared application 42_3

24 to execute, a switch between the overt and covert environments may be

1   implemented. Preferably, a timer event is established to ensure that the shared

2   application 42_3 is periodically scheduled to execute.

3

4   In a generally preemptive operating system environments, such as provided

5   by MS-Windows '95, operating system task switch notification can be utilized to

6   directly execute a portion of the shared application 42_3 on each task switch. Thus,

7   with each task switch, a switch can be made between the overt and covert

8   environments as needed. In other operating systems, including MS-Windows NT

9   and Unix based operating systems that substantially support true preemptive

10   execution of applications, standard system services may be utilized to directly

11   invoke execution of the environment switching portion of the shared application

12   with each context switch implemented by execution of the system scheduler.

13

14   Figure 4 generally shows the preferred reconfiguration of the operating

15   system 40 when supporting application execution in the covert environment. The

16   alternate input queue 76 is effectively swapped for the overt input queue 56.

17   Since the input queues 56, 76 are data storage structures, the contents of the

18   queues 56, 76 are preferably exchange copied on entry and exit of the covert

19   environment. The modified input handler routine 78 is logically installed in place

20   of the input handler 58. Unlike the other alternate data structures and routines,

21   the modified input handler 78 remains resident for the duration of the execution

22   of the environment manager application 42_3. That is, the modified input handler

23   78 manages the input queues 56, 76 in both the overt and covert execution

24   environments for so long as a covert environment exists. This allows the modified

25   input handler 78 to recognize and handle input data for both the overt and covert

1   environments regardless of which environment is currently being supported by the

2   execution of the operation system 40. Also, in order to simplify the

3   implementation of the present invention, the input handler 58 is preserved and

4   used as a dedicated substantive of the new handler 76.

5

6   The display driver jump table 80 is exchange copied with the drawing jump

7   table 66 on entry into and exit from the covert environment. Consequently,

8   during execution within the covert environment, operating system calls are

9   directed through the drawing routine jump table 80 to the covert display driver 82.

10   All conventional applications executing within the covert environment are therefore

11   provided with the full services of what appears to those applications as a

12   conventional display driver.

13

14   In accordance with the present invention, the covert display driver 82 differs

15   from a conventional display driver in that the memory space of window W_3 of the

16   environment manager application 42_3 is utilized as a bit map based display data

17   buffer. That is, all window update events within the covert environment are

18   ultimately realized by the execution of atomic drawing commands executed

19   against the bit map memory space stored in the window W_3. The contents of the

20   window W_3, when transferred as a direct bit map in response to an update event

21   against the overt environment window W_3, properly displays the hierarchial

22   arrangement of windows within the covert environment within the frame of the

23   window W_3 on the display 48.

24

1　　　The covert display driver 82 also differs in that the driver 82 provides for

2　　a duplication and forwarding of all atomic display commands to the operating

3　　system 40 effectively via the environment manager application 42_3.

4　　Consequently, the commands as ultimately forwarded to the operating system 40

5　　preferably includes a logical identification of each collaborative guest 10' that is

6　　to receive the copied atomic display command.

7

8　　　Finally, the covert display driver 82 differs in that an update event is

9　　generated and provided to the overt environment input queue 58 when the

10　　content of the covert display window W_3 is changed. Thus, when the environment

11　　manager application 42_3 swaps back to the overt environment, the relatively

12　　conventional sequence of processing of outstanding update events by the

13　　environment manager application 42_3 in the overt environment context will result

14　　in an efficient updating of the overt environment window W_3 to the display 48.

15

16　　　The relationship between the overt and covert environments in terms of root

17　　window displays is illustrated in Figure 5a and 5b. In Figure 5a, a root window

18　　list entry represents an overt environment root window W_0. A number of

19　　heirarchially related overt application windows W_1-W_{10} are further represented as

20　　window list entries linked beneath the root display list entry. In general, each

21　　application is responsible for updating the representation of its window to the root

22　　display window. The need to update a particular window occurs in response to

23　　the execution of the application that owns the window or the execution of another

24　　application that results in, for example, the exposure of some part of the window.

25　　Updates of a window by the owning application are typically implemented

1 through the generation of drawing events directed to the operating system.

2 Updates due to the execution of other applications typically result in the

3 generation of update events for the applications of the affected windows. Upon

4 execution, applications typically check for and acquire outstanding events awaiting

5 processing by that application. Update events are generically handled by

6 applications through the generation of drawing events for at least the affected

7 portion of the application window.

8

9 Whenever a drawing event is logically directed against a particular one of

10 the dependant windows W_1-W_{10} by an application, the window memory is

11 correspondingly modified. If the modified portion of window is logically visible,

12 atomic drawing commands are issued to render the modification, in bit map form,

13 in a corresponding portion of the display data buffer.

14

15 The environment manager application, when executing in the overt

16 environment, consistently responds to update events for the window W_3 to display

17 the contents of the window W_3 on the root window W_0. Since the contents of the

18 window W_3 exists as a bit map, the update is a bit map transfer of the affected

19 portion of the window W_3 to the display data buffer. The window W_3 therefore

20 appears in the overt environment as a conventional window, generally as

21 represented in Figure 5b.

22

23 The content of the environment manager application window W_3 is

24 determined by the applications that execute within the covert environment. When

25 the operating system 40 is executing in the covert environment, the application list

1   · 60, the tree structured window list pointer 62 and active window pointer 64 are

2   exchange copied with the alternates 70,72,74 stored in the environment manager

3   application 42_3. The root entry of the window list during covert environment

4   execution therefore corresponds to the window W_3. The initial application

5   executing in the covert environment is the environment manager application 42_3.

6   Thus, the initial application list 70 includes only the environment manager

7   application 42_3. The pointer in the active application storage location 72 initially

8   points to this application.

9

10   Again referring to Figure 5a, as applications are subsequently launched

11   and begin to execute in the covert environment, window list entries are created for

12   the windows W_{11}-W_{16} corresponding to the covert applications. As each covert

13   application window is created, manipulated and destroyed, drawing and update

14   events are generated and processed by the covert applications. The covert

15   applications directly or indirectly call the covert display driver 82 with the result

16   that the covert root window W_3 is correspondingly updated.

17

18   Each time execution switches from the covert to the overt environment, the

19   content of the covert root window W_3 properly reflects the visible state of the covert

20   environment application windows. Since a single input queue handler routine 78

21   executes in both overt and covert environments, thereby retaining knowledge of

22   both input queues 56, 76, a covert environment update event can be effectively

23   issued for the environment manager application 42_3 pending a switch to

24   execution in the overt environment. When the overt environment update event is

25   handled, the environment manager application 42_3 correspondingly updates the

1   appropriate visible portion of the covert root window W_3 into the overt window W_3

2   on the overt root display W_0.

3

4   Referring now to Figure 6, a flow chart illustrating the conventional initial

5   flow of operation in an application consistent with the present invention for a

6   cooperatively multitasking operating system is shown. When an application has

7   been loaded by the operating system 40, a start event or equivalent is associated

8   with the application. Until the start event is processed by the operating system 40,

9   the application remains loaded in memory in an effectively suspended state.

10   Generally at the first available opportunity, the start event is processed by the

11   operating system and an initialization routine 100 of the application is executed.

12   The initialization routine 100 performs whatever functions are necessary to

13   initialize the application including, as appropriate, the creation of a window data

14   space and the issuance of requests to establish a predetermined set of window

15   frame decorations, such as pull-down menu lists and scroll bars. Once the

16   application has been initialized, execution passes to a read next event routine

17   102. This routine 102 executes an operating system call that waits on the

18   existence of an input event from the input queue 56 specific to this application.

19   When the operating system 40 determines that such an event exists and should

20   be processed by the application, the operating system call returns with the input

21   data and execution continues with the dispatch event handler 104. The type of

22   input event is determined by the dispatch event handler 104 and an appropriate

23   sub-routine within the application is called. These sub-routines include basic

24   operations such as redraw window 106 which are utilized to handle standard

25   update event inputs as well as other sub-routines specific to the particular function

1   of the application, as illustrated generically by the application specific event

2   routine 108. Another standard event that is dispatched by the dispatch event

3   handler 104 is a terminate event, which is processed by a stop routine 110.

4

5   The corresponding operation of the present invention for cooperatively

6   mutlitasking operating systems is generally shown in Figure 7. Upon start of the

7   environment manager application, the initialization routine 120 is executed. The

8   initializations performed include the following steps:

9

10   1.   Request allocation of memory space for an alternate input queue

11   structure. Initialize the structure to a clear or empty state.

12

13   2.   Request allocation of memory space for a pointer to an alternate

14   tree structured window list.

15

16   3.   Request allocation of an alternate current active window pointer

17   storage location.

18

19   4.   Request allocation of an alternate applications list structure.

20   Initialize the application list structure to a clear or empty state. Insert an initial

21   entry into the application list referencing the Environment Manager application.

22   Insert a pointer to this application in the alternate current active window storage

23   location.

24

1   5.   Execute an operating system call to allocate memory for a covert

2   environment window. Initialize the memory space to represent a predefined

3   background pattern. Request allocation of memory space for a root window list

4   entry and establish a pointer stored in the alternate tree structured window list

5   pointer storage location. Initialize the root window list entry.

6

7   6.   Execute operating system calls to establish window frame

8   decorations for an overt environment window.

9

10   7.   Execute operating systems calls to add menu items to the overt

11   environment window frame to establish links to executable features of the

12   environment manager, including an application selector and launcher for

13   selecting and launching an application in the covert environment (desktop rules

14   may also be implemented at the system configuration level to support the drag

15   and drop of application icons onto the environment manager window to launch

16   the application).

17

18   8.   Replace the input handler routine with the alternate handler routine

19   provided as part of the environment manager application.

20

21   9.   Execute an operating system call to establish an operating system

22   alarm for periodically generating a timer event directed to the environment

23   manager application.

24

1   Execution then continues with the execution of the read event from overt

2   queue step 122. This results in the execution of an operating system call that

3   waits on the existence of an input event in the input queue destined for the

4   environment manager application. The timer event established as part of the

5   initialization routine 120 guarantees that a periodic event will exist for the

6   environment manager application.

7

8   When an event exists for the environment manager application, execution

9   continues with the dispatch to the overt event handler routine 124. The expected

10   events, in a preferred embodiment of the present invention, include timer events,

11   menu selection events, character input events, a termination event and other

12   events related to the manipulation of the window frame and decorations. A

13   combination of menu choice and character input events may be utilized to select

14   an application for launching within the covert environment. When an application

15   is launched in this or an equivalent manner, the application is loaded under the

16   control of the environment manager application into the memory space of the

17   operating system 40 in a suspended state. That is, upon loading the application

18   is added to the application list for the covert rather than overt application list.

19   Consequently, the application will be initialized and begin execution exclusively

20   within the covert environment. Preferably, the operating system top of memory

21   value is used in defining the loading address of the application. Further, this

22   value is preferably stored separate from the application lists and is not modified

23   merely as a consequence of a switch between the overt and covert environments.

24

1   A terminate event is also handled by the dispatch to overt handler routine

2   124. The terminate event causes execution of a terminate routine that provides

3   for the restoration of the input queue handler routine 58. A final copy exchange,

4   as needed, of the various data structures and routines is then performed. Finally,

5   the resources allocated to the environment manager application and any covert

6   applications upon initialization or through execution are released back to the

7   operating system 40.

8

9   When the environment manager application receives a non-terminal overt

10   event from overt queue, execution passes to a decision point routine 126 to

11   determine whether to switch between the overt and covert environments. This

12   decision is made based upon the relative number of pending events in the overt

13   and covert input queues 56, 76. Where the overt queue 56 has the larger

14   number of pending events, execution continues with the read event from overt

15   queue routine 122.

16

17   However, if the covert queue 76 has the larger number of pending events,

18   execution continues with a switch to covert environment routine 128. This routine

19   128 provides for the copy exchange of the application lists 60, 70, pointers to the

20   tree structure window lists 62, 72, and active window pointers 64, 74. The

21   contents of the window queues 56, 76 are also copy exchanged. Finally, the

22   drawing jump tables 66, 80 are copy exchanged to complete the switch to the

23   covert environment. Execution then continues with a read event from covert queue

24   routine 130.

25

1   In executing within the covert environment, a very small number of

2   potential events will be directed to the environment manager. All events

3   associated with the window frame decorations and menus will be generated within

4   the overt environment. Focus events exist for the windows of applications

5   executing within the covert environment. However, the window of the environment

6   manager application is, in effect, the root display of the covert environment.

7   Thus, no covert environment focus events directed to the environment manager

8   are expected. However, timer events continue to occur. The request for periodic

9   timer events made during the execution of the initialization routines 120 remains

10   with the operating system 40 independent of whether the operating system is

11   executing in the overt or covert environments.

12

13   Execution then passes with the event obtained by the read event from covert

14   queue routine 130 to the dispatch to covert handler routine 132. Once an

15   appropriate handler routine has been called and executed, execution then

16   continues to a decision point routine 134. As with the routine 126, the decision

17   point routine 134 determines which input queue has the greater number of

18   pending events. If the covert queue 76 has the greater number of pending events,

19   execution continues with the read event from the covert queue routine 130.

20   Conversely, if the input queue 56 has the greater number of pending events,

21   execution continues with a switch to overt environment routine 136.

22

23   The switch to overt environment routine 136 performs substantially the

24   same function as the switch to covert environment routine 128. The various data

25   structures are copy exchanged between the operating system 40 and environment

1 manager application 42_3. The switch to overt environment routine 136 may enter

2 an update event into the overt input queue 56 for the window corresponding to

3 the environment manager application. Whether this update event is entered

4 depends on whether the covert environment modified any visible portion of the

5 covert root display window W_3. This update event will typically be the next event

6 read from the overt queue by the read event from overt queue routine 122. When

7 read, the event will invoke an update of the environment manager application

8 window to the root window of the overt environment. Thus, updates made to the

9 covert root window due to the execution of applications in the covert environment

10 will be properly reflected in the environment manager application window W_3

11 upon or shortly after a switch is made back to the overt environment

12

13 For the case of a preemptively multi-tasking operating system, or at least

14 where the operating system provides a task switch notification event, the operation

15 of the present invention may be substantially simplified. Rather than requiring the

16 environment manager application to be scheduled and executed as an ordinary

17 application, the environment switching routines provided by the environment

18 manager application can be effectively registered with the operating system and

19 invoked automatically by the operating system in response to each task switch

20 implemented by the operating system. In this case, the initializations described

21 above are performed as part of the initialization of the environment manager

22 application. However, a second applications list is not required. All applications

23 remain visible at all times to the operating system. However, the environment

24 manager tracks which applications are in the overt and covert environments

25 based on the environment in which the application is launched. Specifically,

1   applications launched into the covert environment are launched with the support

2   of the environment manager and can thus be identified as covert environment

3   applications. All other applications are overt environment applications. Thus,

4   upon a task switch to a new task, the environment switching routines of the

5   environment manager are executed. If the application of the task that is the target

6   of the task switch is in a different environment, then data structures are exchange

7   copied as appropriate to switch to the overt or covert environment. No decision

8   as to which environment has the largest number of pending input events, since all

9   input events result in the flagging of corresponding applications as ready to run.

10   By the use of the single application list, the scheduler will properly select

11   applications from both environments to run in a prioritized order.

12

13   A flow diagram illustrating the function of a standard input handler routine

14   58 is shown in Figure 8. As illustrated, an operating system input invent handler

15   sub-routine 140 is responsible for performing the interrupt handling or other low

16   level functions necessary to acquire input data provided via a keyboard or mouse

17   44 or from a communications driver 50 coupled to the operating system 40 as

18   represented by the logical data path 96. This input data is then passed to an add

19   input event to queue routine 142. In the case of simple character input, the

20   intended destination of the input event is the currently active window,

21   determinable from the active window pointer 64. In general for a mouse event,

22   the operating system input focus is changed to the top most window under the

23   mouse pointer at the point of the mouse event. The active window pointer 64 is

24   updated appropriately. Concurrently, an update window event and any other

25   events bound to the mouse event may be created. Each of these events are added

1   to the input queue 56 with the logical destination identified as being the current

2   active window. Execution is then returned to the operating system at 144 as

3   appropriate to allow resumption of the execution of the interrupted application.

4

5   In accordance with the present invention, a new add input event to queue

6   input handler 142 is provided as the handler routine 78 to enable management

7   of both the overt and covert event input queues 56, 76. As shown in Figure 9, an

8   initial decision point determination is made 150 as to whether a new input event

9   is associated with the overt or covert environment. The current active

10   environment, overt or covert, is maintained in a global state variable at all times

11   by the environment manager application. Thus, the active window in the overt

12   environment can be correctly identified from one of the active window pointer

13   storage locations 64,74, regardless of whether the overt or covert environment is

14   active at the time of the input event.

15

16   If the current active window in the overt environment is not the environment

17   manager application, the input event is added to the overt input queue 56 at 152

18   and execution is returned to the operating system at 154. In a preferred

19   embodiment, the event is added to the overt queue 56 under control of the input

20   handler routine 78 and specifically through execution of the handler routine 58.

21   That is, the input handler routine 78 executes to swap in, as necessary, the various

22   data structures appropriate for the overt environment. The input handler 58 is

23   then called to insert the event into the overt queue 56. The state of the

24   corresponding application may also be marked as ready to run in the overt

25   application list. The input handler routine 78 then resumes execution to swap

1   back the various data structures as appropriate to revert to the environment

2   existing when the routine 78 was first called.

3

4   If the overt environment active window for the input event is the window of

5   the environment manager application, a further determination is made as to

6   whether the input event is a mouse event at 156. If the event is not a mouse

7   event, the input data is added to the covert input queue 76 at 158. Again, in a

8   preferred embodiment, the event is added to the covert queue 76 by swapping,

9   if needed, to the covert environment state, executing the input handler routine 58

10   to insert the event and set a corresponding application as ready to run, and

11   swapping back, if needed, to the environment existing when the routine 78 was

12   called. Execution then returns to the operating system at 154.

13

14   Where the mouse event occurs with the mouse pointer within the window

15   of the environment manager application, both input focus and the designation of

16   the current active window in the overt environment remains or is set to the

17   environment manager application. The mouse event must, however, be further

18   localized within the covert environment root display space to associate the mouse

19   event with a potential change of input focus and at least a cursor position change

20   within the covert environment. Accordingly, a translation routine 162 is executed

21   to convert or map the location of the event within the environment manager

22   application window to the covert root window coordinate system. Thus, the mouse

23   pointer location is translated into view window relative coordinates before the

24   event, including the location of the event representing the logical destination of

25   the event, is added to the covert input queue 76 in the same manner as other

1   covert input events are added at 158. Execution then returns to the operating

2   system at 154.

3   If the mouse event occurs with the mouse pointer located outside of the

4   environment manager application window, the mouse event is considered an

5   overt environment event. Thus, the mouse event is added to the overt input queue

6   76 at 152 and execution returns to the operating system at 154.

7

8   Finally, events generated by collaborative guests 10' are passed by the

9   operating system to the environment manager application. These events are

10 always considered to be covert environment events. Therefore, these events 96,

11 as shown in Figure 4, are always added directly to the covert environment queue

12 76. Again, since the current overt or covert environment execution state is

13 maintained by the environment manager application, the current copy exchanged

14 location of the covert input queue 56,76 is determinable. A temporary exchange

15 of the data structures may be performed to facilitate use of the input routine 58

16 to add the event to the covert queue.

17   The present invention can also be implemented as an intrinsic part of the

18 operating system itself. In an operating system such as MS-Windows '95, the

19 essential aspects of the environment manager application can be implemented

20 directly as part of the corresponding portions of the unaltered operating system,

21 thereby minimizing the need to copy exchange data structures. The overt and

22 covert environment input queues can be resident in the operating system and

23 managed by a comprehensive input handler routine. Twin tree structures and

24 active application identifiers, along with an covert environment window buffer can

25 be allocated and managed directly by the operating system. Alternately, a single

1   input queue could be used, though the operating system routines that determine

2   the application for which an event is destined would need to be modified to

3   account for the difference in the overt and covert environment coordinate systems.

4   A single window tree structure could also be used, though again the system

5   routines for walking the tree structure would need to be modified to distinguish

6   between overt and covert environment portions. The covert device driver could

7   be included as a standard part of the operating system or system drivers, since the

8   driver is essentially device independent. Alternately, the function of the covert

9   environment device driver could be modified to selectively operate in line with the

10   conventional display driver. Atomic drawing commands from covert environment

11   applications can be passed to the covert device driver, suitably modified to be

12   covert window relative, and then passed via the jump table 66 to the conventional

13   display device driver. Finally, switching between the overt and covert

14   environments could be provided for as part of the normal operation of the

15   scheduler.

16

17   Thus, a system providing for the establishment of two or more environment

18   spaces for the execution of applications within a common operating system has

19   been described. The alternate execution environments provide a convenient and

20   reliable environment for the execution of applications that may be share among

21   collaborative hosts. The resulting collaborative sessions, by isolation in alternate

22   execution environments, facilitate the execution of both private and shared

23   applications on each collaborative host in a reliable and predictable manner.

24